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Abstract

Preference calibration has been proposed as a method for improving benefit transfers (Smith et al., 2002). The objective of this method is to develop a WTP function that can be used to predict individuals' values for a wide range of quality changes. The analyst's specification of preferences determines the form of this WTP function, and existing empirical studies provide the information that is needed to identify values for its parameters.

The purpose of this paper is to explore and illustrate how the logic of preference calibration can be applied in the area of morbidity valuation. Using relatively simple functional forms for utility, we consider both acute (short-term) and chronic (long-term) illness. To identify values for key preference parameters, we combine information about WTP, health indexes, income, and, in some cases, duration of illness. We then use the calibrated parameters to specify WTP functions. Finally, we demonstrate how these functions can serve as benefit transfer functions, using them to predict WTP for a range of reductions in the severity and/or duration of illness and for different income levels.

Key words: Benefit transfer, preference calibration, health valuation

Subject matter categories: health, valuation

To support regulatory decisionmaking, EPA and other government agencies are faced with a number of statutory and related requirements for conducting cost-benefit analyses (CBA). For example, according to the language of the Safe Drinking Water Act Amendments of 1996, EPA must determine whether the costs of a proposed drinking water safety standard are justified by the benefits. Therefore, particularly for regulations such as these that are designed to protect public health and safety, it is essential for agencies to be able to evaluate how human health will be affected by regulatory alternatives and how these changes are valued by the public.

Due to resource constraints, it is rarely possible for agencies to conduct original primary research aimed at estimating the health benefits associated with specific regulatory options. Instead, analysts must rely on and make best use of information available in existing studies. That is, they must transfer benefits estimated in one context and apply them to the policy context of interest. Because the conditions or focus of existing studies often do not exactly match those of the policy context, this benefit transfer process often requires simplifying assumptions and judgments on the part of the analyst.

One commonly used benefit transfer approach for valuing health benefits is a unit value approach. According to this approach, a value estimate is taken from the literature, such as an average willingness-to-pay (WTP) estimate for avoiding a day with a headache. This value is then applied, like a unit price, to each day of headache that is expected to be avoided through the regulatory action.

Although the unit value approach provides a relatively straightforward and practical way to approximate values for changes in specific health outcomes, it does not attempt to draw any connection between the values that are estimated and the preferences or budget constraints that underlie WTP as a value concept.

As we have described in other papers and reports (Smith et al., Forthcoming; Smith et al., 2002; Smith et al., 2000), the "preference calibration" approach provides a more theoretically consistent method for benefit transfer. The objective of preference calibration is to develop a WTP function that is based on an assumed preference structure and that can be used to predict individuals' values for a wide range of quality changes. The analyst's specification of preferences (e.g., the assumed functional form of the utility function) determines the form of this WTP function. The values for the parameters of this function are identified (i.e., calibrated) using information from existing studies.

The purpose of this paper is to explore and illustrate how the logic of preference calibration can be applied in the area of morbidity valuation. Using relatively simple functional forms for utility, we consider both acute (short-term) and chronic (long-term) illness. To identify values for key preference parameters, we combine information about WTP, health indexes, income, and, in some cases, duration of illness. To keep the analysis more manageable, we also purposefully do not include consideration of values for avoided mortality. In other words, we focus exclusively on WTP for changes in health-related *quality* of life, but not in *quantity* of life (i.e., life expectancy). We demonstrate that, under these conditions, it is possible to develop preference calibrated WTP functions in various ways.

1. Background

One of the main challenges in developing a transferable WTP function for changes in morbidity is identifying an appropriate measure of morbidity. Health outcomes are inherently multidimensional. Whereas changes in the duration or risk of illness can, for the most part, be objectively measured, the same cannot be said for severity of illness. Nevertheless, several health-related quality of life (HRQL) indexes and measurement techniques have been developed and widely applied by health researchers (see Brazier et al. [1999] for a good summary). These methods have primarily been used in cost-effectiveness analyses. Although each of these approaches has limitations for health valuation, they do provide a potentially useful starting point for characterizing changes in morbidity.

Health economists have in particular used three preference-based techniques—visual analog scales, standard gamble (SG), and time tradeoff (TTO)—to develop "utility scores" for a wide variety of health outcomes or conditions. These techniques have also been applied in several "multi-attribute utility score" (MAUS) systems, such as the Quality of Well-Being (QWB) index, the Health Utility Index (HUI), and the EuroQol (EQ-5D), to develop scores for thousands of states, each of which is characterized according to specific dimensions and levels of health. Using these techniques, utility scores generally vary between 0 (representing the death state) and 1 (representing full health). Although there are a number of empirical issues and challenges involved in generating these scores, the SG and TTO approaches in particular are based on explicit theories of choice and expected utility.

The utility-theoretic nature of these preference-based scores makes them particularly informative for preference calibration. They can be directly linked to a preference structure. In all of the applications discussed below, we combine preference-based scores with WTP analyses to calibrate health-related preferences.

It is important to emphasize that preference-based scores are also often used to estimate of changes in quality-adjusted-life-years (QALYs). For this reason, they are often referred to as QALY weights or QALY scores. However, QALYs combine these scores and duration measures in a very specific way. Assuming that any possible health state (i = 1 to N) can be represented by a single score (q_i), if T_i presents the number (or fraction) of life years spent in each health state, i, then the number of QALYs corresponding to a lifetime health profile can be expressed as

$$\text{QALY} = \sum_{i=1}^{N} q_i * T_i \tag{1}$$

As described in this equation, QALYs are often interpreted *as if they represented a utility function*. Clearly, this is a very restrictive specification of preferences. The implications and limitations of using QALYs to represent preferences have been carefully described by Pliskin, Shepard, and Weinstein (1980) and others. To a large extent, the limitations of this form revolve around the fact that duration of illness is assumed to enter utility in a strictly linear way (preferences are risk neutral with respect to duration), and no measure of consumption or utility is included.

In the preference calibration applications described in this section, we do not use the QALY framework, as described in Eq. (1), as a representation of preferences. However, we do make use of measures that are often referred to as "QALY weights" or "QALY scores."

The preference calibration examples described in this section are relatively simple (compared, for example, to the water quality application described in Smith, Van Houtven, and Pattanayak [2002]). They are intended as a first step in illustrating how the logic of preference calibration can be applied in this health context and in exploring what the implications of this approach are for developing utility theoretic benefit transfer functions.

2. WTP for Avoiding Chronic Illness: Preference Calibration Using WTP and SG Information

The approach used here for linking WTP and SG results to a common preference structure requires that (1) these two preference measures apply to the same health condition and (2) average income data are available for the samples used to derive both measures. Although WTP and SG estimates for similar health conditions could, in principle, be drawn from separate studies, in practice it is difficult to find separate studies that meet the two requirements described above. Consequently, we have conducted calibrations where the WTP and SG information come from the same study.

In the first calibration example, we use a study by O'Brien and Viramontes (1994). Based on a sample of 102 persons with chronic lung disease (mean age 62 years; 54% male), the study applied three different approaches to evaluate health-based preferences. The first two approaches—rating scale and standard gamble (SG)—were used to generate utility weights for respondents' current health status. The other approach was to elicit respondents' WTP for a treatment that would cure the lung disease. To conduct the preference calibration, we make use of the SG and the WTP components of the study.

Standard Gamble: The SG question was fairly standard. One option was to remain in current health (H^*) for the remainder of one's life; the other was a gamble between immediate death (H_0) or healthy lung function (H_1) for the rest of life.

WTP: This question (using a bidding game approach) asked respondents for their maximum WTP for a treatment that had a 1% chance of immediate death and a 99% chance of healthy lung function.

Through the logic of preference calibration, it is possible to link these two separate pieces of value information back to a common preference structure and, in doing so, use the information to identify preference parameters (in this simple case, a single parameter).

We begin by specifying a simple Cobb-Douglas form for the utility function with respect to income (Y) and health (H)

$$U(Y,H) = Y^{\alpha}H^{\beta} \tag{2}$$

This form implies that the marginal utility of income is positively related to health and the marginal utility of health is positively related to income. It also implies "standard gamble invariance" with respect to income (i.e., p_s^* for any health state, H^*, should not vary with income).[1]

The response to the SG question, implies that individuals select a probability of survival (p_s^*), such that the following equality holds

$$U(Y,H^*) = p_s^{*}U(Y,H_1) + (1 - p_s^{*})U(Y,H_0) \tag{3}$$

Assuming that utility in the death state is equal to zero (the second term drops out), this expression can be rewritten as:

$$U(Y,H^*) = p_s^{*}Y^{\alpha}H_1^{\beta} \tag{4}$$

[1]Duration of illness is not explicitly included in this preference function; however, it is implicitly the same for both the SG and WTP cases (i.e., rest of life). If duration were included as an additional multiplicative term in the Cobb-Douglas specification it would not alter the results.

The response to the WTP question, implies that individuals select a WTP for the specified treatment (W) such that the following equality holds:

$$\mathrm{U}(\mathrm{Y},\mathrm{H}^{*}) = (0.99)\mathrm{U}(\mathrm{Y}-\mathrm{W},\mathrm{H}_{1}) + (0.01)\mathrm{U}(\mathrm{Y}-\mathrm{W},\mathrm{H}_{0}) \tag{5}$$

Assuming again that utility in the death state is equal to zero implies that

$$\mathrm{U}(\mathrm{Y},\mathrm{H}^{*}) = (0.99)(\mathrm{Y}-\mathrm{W})^{\alpha}\mathrm{H}_{1}^{\beta} \tag{6}$$

Setting Eq. (4) and Eq. (6) equal to one another, it is possible to derive the following expression for the income elasticity parameter:

$$\alpha = \frac{\ln(p_{s}^{*}/(0.99)}{\ln(Y-W/Y)} \tag{7}$$

Using sample means and estimates from O'Brien and Viramontes (1994)—p_s* = 0.83, W = \$1,356, Y = \$27,000—the calibration result for the parameter is

$$\hat{\alpha} = 3.437$$

Using the assumed utility structure, it is also possible to specify a calibrated WTP function. That is, for any health state (H^{**}) for which we have a comparable SG estimate (p_s^{**}), the following equality should hold

$$\mathrm{U}(\mathrm{Y},\mathrm{H}^{**}) = (\mathrm{p}_{s}^{**})\mathrm{Y}^{\alpha}\mathrm{H}_{1}^{\beta} = (\mathrm{Y}-\mathrm{WTP}^{**})^{\alpha}\mathrm{H}_{1}^{\beta} \tag{8}$$

Rearranging this equation, we get the following expression for WTP

$$WTP^{**} = (1-p_{s}^{**(1/\hat{\alpha})})Y = (1-p_{s}^{**(0.291)})Y \tag{9}$$

Eq. (9) represents the calibrated WTP function. As shown in Table 1, this function can serve as a preference calibrated benefit transfer function to estimate the value of an avoided chronic illness, based on SG scores and income level. In Table 1, WTP is estimated for SG scores varying between 0.45 and 0.95 and for incomes of \$25,000 and \$40,000.

In the second calibration example, we use a study by Thompson (1986). This study is based on a sample of 247 persons suffering from rheumatoid arthritis. This study also used both a SG and a WTP approach for eliciting preferences.

- *Standard Gamble*: As in the O'Brien and Viramontes study, the SG question used was fairly standard. One option was to remain in current health (H^*) for the remainder of one's life; the other was a gamble between immediate death (H_0) or a complete cure of arthritis (H_1) for the rest of life.

- *WTP*: This question asked respondents for the maximum *percentage* (t) of income they would be willing to pay for a complete cure of arthritis.

In this case, the response to the WTP question implies that individuals select a WTP (as a percent of income) such that the following equality holds

$$\mathrm{U}(\mathrm{Y}, \mathrm{H}^*) = \mathrm{U}((1-\mathrm{z}) * \mathrm{Y}, \mathrm{H}_1) \tag{10}$$

This implies the following expression for the income elasticity parameter:

$$\alpha = \frac{\ln(p_S{}^*)}{\ln(z)} \tag{11}$$

Using sample means and estimates from the Thompson study—$p_s^* = 0.73$ and $z = 0.22$—the calibration result for the parameter is

$$\hat{\alpha} = 1.267 \tag{12}$$

Applying this parameter value to Eq. (9), it is again possible to produce a preference calibrated benefit transfer function to estimate the value of an avoided chronic illness. In this case:

$$WTP^{**} = (1 - p_s{}^{**(1/\hat{\alpha})})Y = (1 - p_s{}^{**(0.789)})Y \tag{13}$$

This recalibrated function is also use in Table 1 to estimate annual WTP values for SG scores varying between 0.45 and 0.95 and for incomes of $25,000 and $40,000. Given the differences between the O'Brien and Viramontes and the Thompson studies (WTP as a percentage of income is much less in the former study), it is not surprising that the resulting values are considerably higher for this recalibrated function.

In both of the examples discussed above, the WTP and SG estimates come from the same sample of individuals. It should be noted, however, that calibration of this preference function would still be possible if the WTP and SG estimates came from different samples (i.e., with different incomes) as long as they are used to evaluate the same health condition.

3. WTP for Avoiding Chronic Illness: Preference Calibration Using WTP and TTO Information

To apply the results of a TTO study to conduct a similar calibration, it is necessary to be more explicit about how the duration of illness enters the preference function. Therefore, we specify the following expanded function:

$$U(Y, H, L) = Y^{\alpha} H^{\beta} L^{\gamma} \tag{14}$$

In this function L represents the duration of the health state.[2]

In this case, annual WTP to avoid a chronic health state, H^*, can be expressed as

$$U(Y, H^*, L) = Y^{\alpha} H^{*\beta} L^{\gamma} = (Y - W)^{\alpha} H_1{}^{\beta} L^{\gamma} \tag{15}$$

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[2]Note that if the same utility function were used in the WTP and SG example, the duration term would have dropped out of the calculations and not affected the results. With this utility function, neither the annual WTP to avoid a chronic health state nor the SG score for a chronic health state are sensitive to the duration of the health state.

As can be seen from this expression, W (*annual* WTP) will not vary with respect to the duration of illness (i.e., number of years with illness).

A TTO question asks respondents to choose the number of years in perfect health (L_1) that would provide the same level of utility as L^* years in the chronic health state. This equivalence can be expressed as:

$$U(Y, H^*, L) = Y^{\alpha} H^{*\beta} L^{*\gamma} = Y^{\alpha} H_1^{\beta} (L_1)^{\gamma} = Y^{\alpha} H_1^{\beta} (t^* L^*)^{\gamma} \tag{16}$$

In this expression $t^* = L_1/L^*$ is the utility score derived from the TTO approach. Using this preference function implies that t^* will also not vary with respect to the duration of illness.

Combining Eq. (15) and Eq. (16) results in the following expression for the preference parameters:

$$\theta = \alpha / \gamma = \frac{\ln(t^*)}{\ln(Y - W / Y)} \tag{17}$$

This equation implies that the *ratio* of the two parameters can be calibrated, but they cannot be separately identified. However, the WTP function corresponding to this preference structure is also in terms of the ratio of these two parameters. For a health condition with a TTO score of t^{**}, the corresponding WTP is:

$$WTP^{**} = (1 - t^{**(1/\theta)})Y \tag{18}$$

To illustrate preference calibration using WTP and TTO estimates, we use information from a study by Lundberg et al. (1999). As part of this Swedish study, 366 patients with psoriasis or atopic eczema (ages 17 to 73) were asked both a TTO question for their illness and a maximum WTP question for a cure for their illness. Based on a bidding game approach, the average annual WTP was $1,420. The average annual income of the sample was \$16,284, and the average TTO score was 0.9. Applying these values to Eq. (17) results in the following calibrated value for the parameter ratio:

$$\hat{\theta} = 1.156 \tag{19}$$

Applying this calibrated parameter ratio to Eq. (18), it is again possible to estimate annual WTP values (in this case for TTO scores varying between 0.45 and 0.95 and for incomes of \$25,000 and \$40,000). These results are also summarized in Table 1. With this calibrated function, the WTP estimates are closer in value and slightly larger than those based on the calibration based on the Thompson SG study.

4. WTP for Avoiding Acute Illness

To calibrate preferences for avoiding acute illness, we assume that acute conditions last for one year or less, and we specify the following function to represent annual utility:

$$U(Y, q, L) = Y^{\alpha}(1 - L^{\beta}) + Y^{\alpha}qL^{\beta} = Y^{\alpha}(1 - \Delta qL^{\beta}) \tag{20}$$

In this expression:

Y = annual income

q = health index for acute condition ($0 < q < 1$)

L = fraction of a year spent with the acute condition

Δq = $1 - q$

According to this specification, if an individual spends the entire year with the acute condition ($L = 1$), then annual utility can be written as:

$$U(Y, q, 1) = Y^{\alpha}q \tag{21}$$

Therefore, q can be thought of as the SG or visual analog utility score corresponding to 1 year in the health state.

If, on the other hand, the individual spends the entire year in perfect health ($q = 1$), then annual utility can be expressed as

$$U(Y,1,0) = Y^{\alpha} \tag{22}$$

Otherwise, annual utility is like a weighted average of utlity in perfect health and utility with acute illness, where the weights are $1 - L^{\beta}$ and L^{β}, respectively. If $\beta < 1$, this implies marginal disutility is decreasing with respect to the length of acute illness.

According to this utility specfication, WTP for a nonmarginal reduction in the length of acute illness (from L_1 to L_2) can be expressed as:

$$Y^{\alpha}(1 - \Delta q L_1{}^{\beta}) = (Y - WTP)^{\alpha}(1 - \Delta q L_2{}^{\beta}) \tag{23}$$

Rearranging this expression, WTP can then be expressed by the following equation:

$$WTP = Y - Y\left(\frac{1 - \Delta q L_1{}^{\beta}}{1 - \Delta q L_2{}^{\beta}}\right)^{1/\alpha} \tag{24}$$

To calibrate the two preference parameters, it is necessary to have two separate pieces of information linking Δq, Y, L_1, L_2, and WTP. A large number of WTP estimates for avoided acute effects are currently available from the literature (Johnson et al., 1997; Van Houtven et al., 2003). To illustrate how this function can be calibrated, we select two observations from the literature. These values were selected to provide a range of values for Δq, Y, L_1, and L_2.

The first observation is from Johnson et al. (2000), which uses conjoint analysis to assess values for a wide variety of acute respiratory effects. Based on a sample of 399 Canadian respondents, with an average annual income of $47,067, Johnson et al. estimate an average annual WTP of $460 to reduce the number of days of hospitalization with chest and arm pain from 1 to zero days. The acute condition described by Johnson et al. corresponds to a combined QWB scored of 0.428 ($\Delta q = 1 - 0.428 = 0.572$).

The second observation is from Chestnut et al. (1996), which uses contingent valuation to assess values for avoided angina episodes. Based on a sample of 22 angina sufferers, with an average of 15.4 episodes per year and average income of $35,208, this study estimates an average annual WTP of $325 to reduce the number of episodes by 4. The acute condition described by Chestnut et al. corresponds to a combined QWB scored of 0.639 ($\Delta q = 1 - 0.639 = 0.361$).

To perform the calibration, we first rearranged Eq. (24) to isolate one of the parameters on the LHS as follows:

$$\alpha = \frac{\ln\left(\dfrac{1 - \Delta q L_1{}^{\beta}}{1 - \Delta q L_2{}^{\beta}}\right)}{\ln((Y - WTP)/Y)} \tag{25}$$

Selecting a single value for β, we then used information from the two observations to estimate two separate values for α. We then searched over alternative values of β until the two α values converged to the same value. This calibration process resulted in the following parameter estimates:

$$\hat{\alpha} = 0.7152$$

$$\hat{\beta} = 0.74646$$

With these calibrated parameters, it is then possible to use Eq. (24) to estimate annual WTP for any combination of Δq, Y, L_1, and L_2. That is, it can be used as a benefit transfer function.

Table 2 reports WTP estimates based on this calibrated function for values of Δq ranging between 0.2 and 0.5, values of Y between $25,000 and $50,000 and duration changes between 1 and 20 days. The values range from \$85 to avoid 1 day of a relatively minor acute condition (with income of \$25,000) to almost \$4,000 for avoiding 20 days of very severe illness (e.g., requiring hospitalization) with \$50,000. These estimates are relatively large for acute conditions, but they are consistent with the values selected for the calibration.

5. Conclusions

The purpose of this paper has been to explore and illustrate how the logic of preference calibration can be applied in the area of morbidity valuation. Using relatively simple functional forms for utility, we demonstrated preference calibration for both chronic and acute illness. In both cases we selected WTP and QALY score estimates for a common condition, and showed how they could be linked to a common preference structure. Using additional information about average income and, in certain cases, duration of illness, we calibrated parameters of the assumed preference structure.

By specifying the underlying utility function, we were also able in each case to specify the corresponding WTP function. This function includes the calibrated parameters, as well as the severity of illness avoided (through the selected health index), income, and, in the case of acute illness, the reduction in duration of illness. To demonstrate how this function can be used as a flexible benefit transfer function, we used the calibrated functions to estimate WTP for a range of illness severity indexes, income levels, and durations of illness.

Through these examples we show that it is possible to identify the values of key preference parameters using a limited amount of information from existing studies. However, as is the case with any benefit transfer process, the results vary depending on which study or value is selected for the analysis. As the number of available studies and values increases, it makes sense to treat this as a statistical estimation rather than as a calibration problem. Statistical meta-analysis techniques are now commonly used for benefit transfer as a way to integrate information from a large number of studies. In principle, these same techniques can be applied to estimate, rather than calibrate, the WTP functions described in this paper. Conducting "structural" meta-analyses of this sort is an important topic for future research.

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7. References

Brazier, J., M. Deverill, C. Green, R. Harper, and A. Booth. 1999. "A Review of the Use of Health Status Measures in Economic Evaluation." *Health Technology Assessment* 3(9):1-160.

Chestnut, Lauraine G., L. Robin Keller, William E. Lambert, and Robert D. Rowe. 1996. "Measuring Heart Patients' Willingness to Pay for Changes in Angina Symptoms." *Medical Decision Making* 16:65-77.

Johnson, F.R., E.E. Fries, and H.S. Banzhaf. 1997. "Valuing Morbidity: An Integration of the Willingness-to-Pay and Health-Status Index Literatures." *Journal of Health Economics* 16:641-665.

Johnson, F.R., Melissa R. Banzhaf, and William H. Desvousges. 2000. “Willingness to Pay for Improved Respiratory and Cardiovascular Health: A Multiple-Format Stated-Preference Approach.” *Health Economics* 9:295-317.

Lundberg L., et al. 1999. “Quality of Life, Health-State Utilities and WTP in Patients with Psoriasis and Atopic Eczema.” *Br J Dermatol* 141(6):1067-75.

O’Brien, Bernie J., and Jose Luis Viramontes. 1994. “Willingness to Pay: A Valid and Reliable Measure of Health State Preferences?” *Medical Decision Making* 14(3):289-297.

Pliskin, J.S., D.S. Shepard, and M.C. Weinstein. 1980. “Utility Functions for Life Years and Health Status.” *Operations Research* 28:206-24.

Smith, V.K., Van Houtven, G.L., S.K. Pattanayak, and T.H. Bingham. 2000. *Improving the Practice of Benefit Transfer: A Preference Calibration Approach*. Interim Final Report prepared for the U.S. Environmental Protection Agency’s Office of Water and Office of Policy, Economics, and Innovation.

Smith, V.K., Van Houtven, G.L., and S.K. Pattanayak. 2002. “Benefit Transfer Via Preference Calibration” ‘Prudential Algebra’ for Policy.” *Land Economics* 78(1):132-152.

Smith, V.K., S.K. Pattanayak, and G.L. Van Houtven. Forthcoming. “VSL Reconsidered: What Do Labor Supply Estimates Reveal About Risk Preferences?” *Economics Letters*.

Thompson, Mark S. 1986. "Willingness to Pay and Accept Risks to Cure Chronic Disease." *American Journal of Public Health* 76(4):392-396.

Van Houtven, G., Rousu, M., Yang, J.-C., Pringle, C. Wagstaff, W. and J. De Platchett. 2003. "Valuation of Morbidity Losses: Meta-Analysis of Willingness-to-Pay and Health Status Measures." Prepared for the Food and Drug Administration's Center for Food Safety and Applied Nutrition.

Table 1. WTP for Avoided Chronic Illness: Estimates Based on Calibrated WTP Functions

		Annual WTP Estimate		
Utility Score SG (p) or TTO (t)	Annual Income (Y)	O'Brien et al. SG Calibration[a]	Thompson SG Calibration[b]	Lundberg et al. TTO Calibration[c]
0.95	$25,000	$370	$992	$1,085
0.9	$25,000	$755	$1,995	$2,178
0.85	$25,000	$1,155	$3,010	$3,280
0.8	$25,000	$1,572	$4,038	$4,390
0.75	$25,000	$2,008	$5,079	$5,509
0.7	$25,000	$2,465	$6,135	$6,639
0.65	$25,000	$2,945	$7,208	$7,779
0.6	$25,000	$3,453	$8,297	$8,932
0.55	$25,000	$3,992	$9,406	$10,097
0.5	$25,000	$4,566	$10,536	$11,277
0.45	$25,000	$5,183	$11,691	$12,473
0.95	$40,000	$593	$1,587	$1,737
0.9	$40,000	$1,208	$3,193	$3,485
0.85	$40,000	$1,848	$4,817	$5,248
0.8	$40,000	$2,515	$6,461	$7,024

Utility Score SG (p) or TTO (t)	Annual Income (Y)	Annual WTP Estimate		
		O'Brien et al. SG Calibration[a]	Thompson SG Calibration[b]	Lundberg et al. TTO Calibration[c]
0.75	$40,000	$3,212	$8,127	$8,815
0.7	$40,000	$3,943	$9,817	$10,622
0.65	$40,000	$4,712	$11,532	$12,447
0.6	$40,000	$5,525	$13,275	$14,291
0.55	$40,000	$6,387	$15,050	$16,155
0.5	$40,000	$7,306	$16,858	$18,043
0.45	$40,000	$8,293	$18,705	$19,956

[a]based on Eq. ( ) alpha = 3.437

[b]based on Eq ( ) alpha = 1.267

[c]based on Eq ( ) theta = 1.156

Table 2. WTP for Avoided Acute Illness: Estimates Based on Calibrated WTP Function

Annual Income (Y)	Health Status Change (Δq)	Before Change Duration (L1)	After Change Duration (L2)	Annual WTP Estimate
$25,000	0.2	20	0	$796
$25,000	0.2	10	0	$475
$25,000	0.2	5	0	$284
$25,000	0.2	1	0	$85
$25,000	0.2	20	15	$157
$25,000	0.2	20	10	$327
$25,000	0.2	20	5	$518
$25,000	0.5	20	0	$1,977
$25,000	0.5	10	0	$1,184
$25,000	0.5	5	0	$708
$25,000	0.5	1	0	$213
$25,000	0.5	20	15	$404
$25,000	0.5	20	10	$832
$25,000	0.5	20	5	$1,306
$50,000	0.2	20	0	$1,592
$50,000	0.2	10	0	$951
$50,000	0.2	5	0	$567

Annual Income (Y)	Health Status Change (Δq)	Before Change Duration (L1)	After Change Duration (L2)	Annual WTP Estimate
$50,000	0.2	1	0	$171
$50,000	0.2	20	15	$315
$50,000	0.2	20	10	$654
$50,000	0.2	20	5	$1,037
$50,000	0.5	20	0	$3,953
$50,000	0.5	10	0	$2,368
$50,000	0.5	5	0	$1,415
$50,000	0.5	1	0	$427
$50,000	0.5	20	15	$808
$50,000	0.5	20	10	$1,665
$50,000	0.5	20	5	$2,612